ECOLOGY AND EVOLUTION OF DARTERS: CURRENT STATUS
AND FUTURE RESEARCH NEEDS
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Darters (Subfamily Etheostomatinae) represent one of the most fascinating examples of morphological, behavioral, ecological, and genetic radiation in North America. Darters are one of the most speciose groups of North American freshwater fishes, with over 200 species/subspecies. The high degree of darter diversity is believed to be the result of two factors: adaptation to habitat and sexual selection. As a result, darters are a model group for studies of adaptive radiation and diversification. The eminent ichthyologist and statesman David Starr Jordan (1922) recognized the exceptionality of this group when he stated, "These (darters) we found to be the most fascinating, vivacious, and individual of all river fishes."

Until recently, studies of darter diversity focused on alpha level taxonomy, specifically, describing species and documenting levels of morphological diversity. In the last decade, darter biologists have undertaken phylogenetic studies to examine relationships among species, subgenera, and genera. Interest in darter diversity and systematics has increased dramatically, primarily due to the usage of DNA sequence data. Most studies have relied on mitochondrial DNA, particularly cytochrome b, to address particular evolutionary questions. As a result, we are now beginning to have a clearer understanding of the evolutionary history of this group, and consequently, are re-evaluating darter taxonomy in light of this new data. Future research needs to build on the results from previous studies and should proceed in the direction of multi-gene phylogenies that incorporate multiple nuclear and mtDNA markers. However, one of the unfortunate aspects of systematic and taxonomy studies is the lack of adequate funding sources. At present, the National Science Foundation is the primary funding source for systematic and taxonomic studies. Developing a comprehensive understanding of the diversity and evolutionary history of darters will likely require additional funding sources and collaborative efforts among multiple researchers.

Although darters are relatively unknown to most of society, they represent an important component of riverine ecosystems in the Eastern United States. Darter biologists would argue that particular species of darters (i.e. Crystallaria aspella) are some of the most important aquatic species for environmental protection. Darters are important because they are "indicator species" for aquatic environments. When riverine systems are perturbed through human modifications, such as dam construction or channelization, darters are often the first group of organisms to become imperiled, and often extirpated. In fact, one species, the Maryland darter (Etheostoma sellare) is already believed to be extinct, prior to understanding its habitat requirements and other aspects of its ecology. We lack comprehensive life-history information for many darters. Additional research is needed to better understand basic aspects of habitat, reproduction, and feeding if we are to conserve darter populations and their respective riverine systems. These types of studies represent an important and often overlooked component of species conservation.

Routine conservation status surveys addressing levels of imperilment in jeopardized darters are necessary for the development of an effective management plan for many species. Although the results from these types of studies are critical for managing and protecting darters, they are often conducted over relatively short periods (1 or 2 years). Documentation of long-term abundance and distributional changes, through multi-year studies or incorporation of museum data, are needed to provide a more comprehensive view of demographic and distributional changes among jeopardized darters.

An equally important aspect of species conservation, but one that is less often pursued, is the incorporation of molecular markers to address levels of genetic diversity within populations. Molecular genetic data routinely are incorporated into the management of salmonids, centrarchids, or other sportfishes, but less often utilized for non-game species including darters. Usage of high-resolution markers including microsatellites or AFLP's, have increased our effectiveness in managing fish populations. Future research should use these types of techniques, as they can provide useful information that can guide re-introduction efforts, monitor gene flow between populations, and document distinct temporal changes in genetic diversity among darters.

Finally, comparing patterns of endangerment of darters and other aquatic groups may shed light on the factors that concurrently have impacted aquatic species. The life-history of mussels, one of the most imperiled groups of organisms in North America, is often tied to population sizes of sympatric species of fishes. Darters serve as glochidial hosts for many species of mussels, particularly in the Interior and Ozark-Ouachita Highland regions, where darter and mussel diversity is greatest. Understanding the relationship between mussel and darter diversities and population sizes may prove to shed light on the mechanisms of endangerment within both the unionid mussels and Etheostomatine darters.